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MODIFIED MPPT SCHEME FOR IMPROVING SOLAR CELL POWER OUTPUT FOR MULTI-INPUT INVERTER

HARIHARAN.R[1], HARIHARAN.Ve[2], ASHOK.B[3], SURENDHARAN.P[4]
[1,2,3,4]Electrical and Electronics Engineering, Vel Tech, Chennai, INDIA

Abstract- The performance of a photovoltaic (PV) module is mostly affected by array configuration, irradiance, and module temperature. It is important to understand the relationship between these effects and the output power of the PV array. This paper proposes an adaptive control architecture for maximum power point tracking (MPPT) in photovoltaic systems. MPPT technologies have been used in photovoltaic systems to deliver the maximum available power to the load under changes of the solar insolation and ambient temperature. To improve the performance of MPPT, this paper develops a two-level adaptive control architecture that can reduce complexity in system control and effectively handle the uncertainties and perturbations in the photovoltaic systems and the environment. The first level of control is ripple correlation control (RCC), and the second level is model reference adaptive control (MRAC). By decoupling these two control algorithms, the system achieves MPPT with overall system stability. This paper focuses mostly on the design of the MRAC algorithm, which compensates the under damped characteristics of the power conversion system. The original transfer function of the power conversion system has time-varying parameters, and its step response contains oscillatory transients that vanish slowly. An adaption law of the controller is derived for the MRAC system to eliminate the under damped modes in power conversion. It is shown that the proposed control algorithm enables the system to converge to the maximum power point in milliseconds.

Index Terms—Maximum power point tracking (MPPT), model reference adaptive control (MRAC), photovoltaic system, ripple correlation control (RCC).

I. INTRODUCTION

PHOTOVOLTAIC systems are a critical component in addressing the national mandates of achieving energy independence and reducing the potentially harmful environmental effects caused by increased carbon emissions. Due to variations in solar insolation and environmental temperature, photovoltaic systems do not continually deliver their theoretical optimal power unless a maximum power point tracking (MPPT) algorithm is used. MPPT algorithms are designed in order for the photovoltaic system to adapt to environmental changes so that optimal power is delivered. Typically, MPPT algorithms are integrated into power electronic converter systems, where the

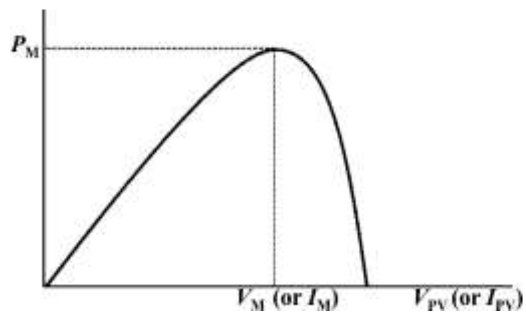

Fig. 1.Power–voltage characteristics of photovoltaic systems.

duty cycle of the converter is controlled to deliver maximum available power to the load [1], [2].

Several MPPT algorithms have been reported in the literature. The most common of these algorithms is the perturb and observe (P&O) method [3]–[5]. This control strategy requires external circuitry to repeatedly perturb the array voltage and subsequently measure the resulting change in the output power. While P&O is inexpensive and relatively simple, the algorithm is inefficient in the steady state because it forces the system to oscillate around the maximum power point (MPP) instead of continually tracking it. Furthermore, the P&O algorithm fails under rapidly changing environmental conditions, because it cannot discern the difference between changes in power due to environmental effects versus changes in power due to the inherent perturbation of the algorithm [6]. The incremental conductance (INC) method uses the fact that the derivative of the array power with respect to the array voltage is ideally zero at the MPPT(seeFig.1), positive to the left of the MPP, and negative to the right of the MPP. The INC method has been shown to perform well under rapidly changing environmental conditions, but at the

expense of increased response times due to complex hardware and software requirements [7]. The fractional open-circuit voltage (FOCV) method uses an approximate relationship between V_{OC}, the open-circuit voltage of the array, and V_M, the array voltage at which maximum power is obtained, to track the MPP [8]. Like P&O, the FOCV algorithm is inexpensive and can be implemented in a fairly straight-forward manner. However, the FOCV method is not a true MPP tracker since the assumed relationship between V_{OC} and V_M is only an approximation. Fuzzy logic and neural network-based algorithms have demonstrated fast convergence and high performance under varying environmental conditions, but the implementation of these algorithms can be undesirably complex [9], [10]. To this end, a general problem associated with MPPT algorithms is the transient oscillations in the system's output voltage after the duty cycle is rapidly changed in order to track the MPP [7]. Thus, the ideal MPPT control algorithm would be simple and inexpensive, and would demonstrate rapid convergence to the MPP with minimal oscillation in the output voltage.

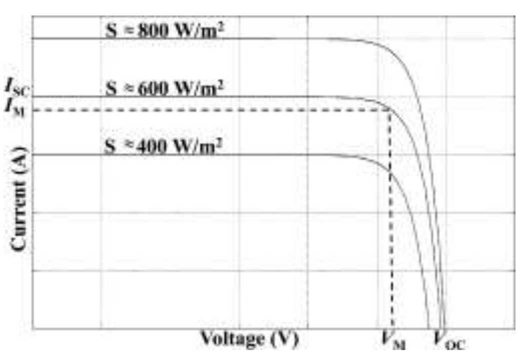

Fig. 2. Current–voltage characteristics of photovoltaic systems under various levels of solar insolation.

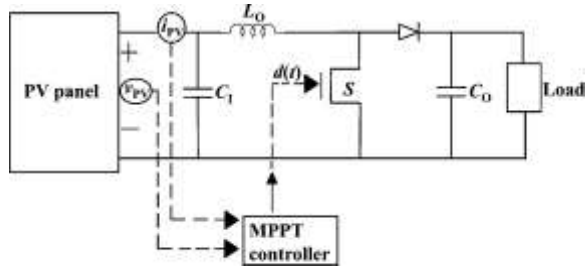

Fig. 3. MPPT controller of a photovoltaic boost converter system

II.EXISTING SYSTEM

Petrub and Observe method works by disrupting the system and observing the impact on power output of PV module. If the operating voltage is disturbed in a given direction and that the power increases (dP/dV > 0) then it is clear that the disturbance has moved the operating point toward the MPP. The P&O algorithm will continue to disturb the voltage in the same direction. By cons, if the power drops (dP/dV < 0), then the disturbance has moved the operating point far from the MPP. The algorithm will reverse the direction of subsequent disturbance. This algorithm is summarized in the flowchart (Fig 4).

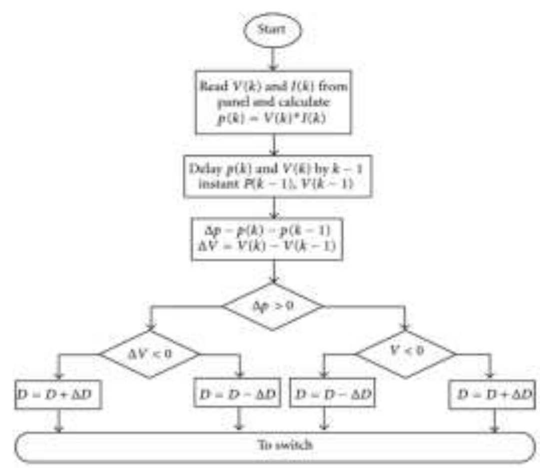

Fig.4.Flowchart of P&O

III.PROPOSED SYSTEM

This paper develops a two-level MPPT control algorithm that consists of ripple correlation control (RCC) [11]–[14] in the first level and model reference adaptive control (MRAC) [15], [16] in the second level. As shown in Fig. 4, in the first control level the array voltage v_{PV} and power p_{PV} serve as the

inputs to the RCC unit. The RCC unit then calculates the duty cycle of the system, $d(t)$, to deliver the maximum available power to the load in the steady state. In the second control level, the new duty cycle calculated from the RCC unit is routed into an MRAC architecture, where the dynamics of the entire photovoltaic power conversion system, or the plant, are improved to eliminate any potential transient oscillations in the system's output voltage. Transient oscillations in the system's output voltage can result after the duty cycle has been updated to account for rapidly changing environmental conditions. To prevent the plant from displaying such oscillations, a critically damped system is implemented as the reference model in Fig. 5. During adaptation, the error between the plant and reference model is utilized to tune the parameters in the feedforward and feedback controllers, C_f and C_b, respectively. Properly tuning the controller parameters enables the output of the plant to match the output of the reference model, at which point the error converges to zero and the maximum power is obtained. Both the theoretical and simulation results demonstrate convergence to the optimal power point with elimination of underdamped responses that are often observed in photovoltaic power converter systems.

The proposed two-level controller structure can reduce the complexity in system control, with RCC mainly handling the "slow" dynamics and MRAC handling the "fast" dynamics. The previous literature has proven the stability of RCC and MRAC, respectively. Although coupling two stable subsystems will not necessarily lead to the stability of the overall system, our proposed two-level structure can effectively decouple the RCC and MRAC levels in stability analysis, because the time constants of the two control algorithms used here are significantly disparate. This paper focuses mostly on the MRAC level of the proposed control architecture. In a sequel paper (in preparation), we will provide a comprehensive analysis validating the coupling of MRACwithRCC.

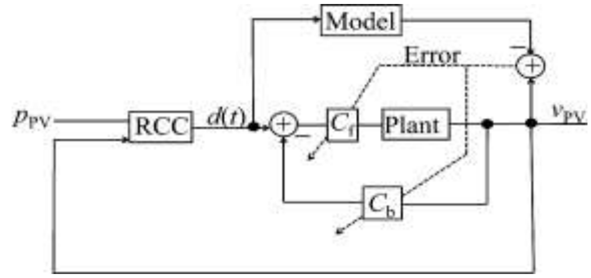

Fig. 5 Proposed MPPT control architecture

IV.SYSTEM DESCRIPTION

Fig. 2 presents the current–voltage (I–V) characteristics of photovoltaic systems under various levels of solar insolation. The MPP occurs at the so-called "knee" of the I–V curve, (V_M,I_M): when either V_M or I_M is achieved, the maximum available power P_M is obtained.

A photovoltaic system can regulate the voltage or current of the solar panel using a dc–dc converter interfaced with an MPPT controller to deliver the maximum allowable power [17], [18]. Fig. 4 shows the integration of such a system where a boost converter is utilized to deliver optimal power to the load. Depending on the application, other power converter topologies may be used in place of the boost converter. In the boost converter system shown in Fig. 4, the MPPT controller senses the voltage and current of the solar panel and yields the duty cycle d to the switching transistor S. The duty cycle of the transistor is related to the array voltage through

$$v_{PV} = i_{PV} R_O (1 - d)^2$$

where v_{PV} and i_{PV} are the array voltage and current, respectively, and R_O is the load resistance. Both the array voltage and current consist of dc (average) terms, V_{PV} and I_{PV}, as well as ripple terms, $\hat{v}_{PV}$ and $\hat{i}_{PV}$. The goal then is to design a controller that continually calculates the optimal value of the duty cycle so that V_{PV} tracks V_M (or I_{PV} tracks I_M) and thus delivers the maximum available power.

V.SIMULATION DIAGRAM AND GRAPH

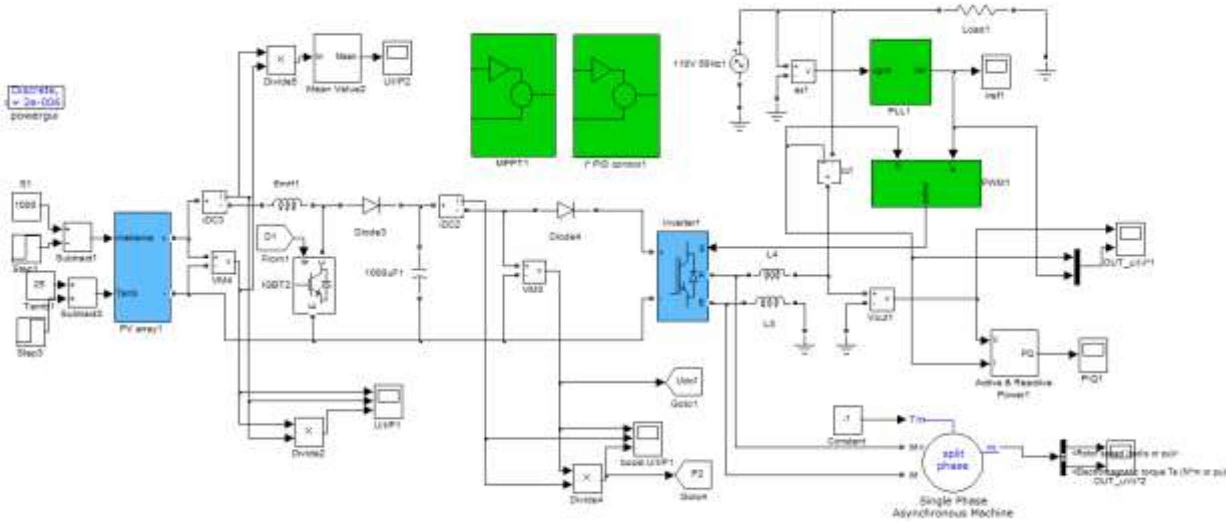

Fig.6.Simulation Diagram of P&O and MRAC

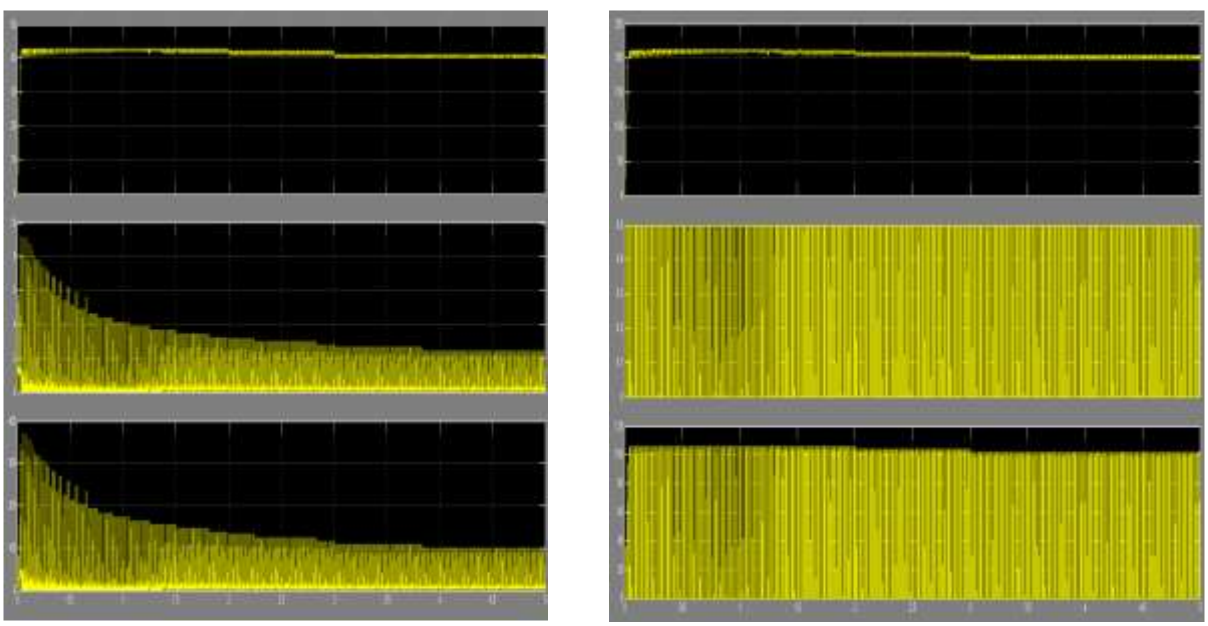

Fig.7.OutputGraph

In Fig.7 a comparison between input voltage and the boosted voltage has been given. When you take a look at the graph 7.a the input voltage is of 41v and the input current is of 1.637A which combines to give a power of 67.09 W. Considering the given input the boosted output should be such that the power and

voltage increases with less settling time. The Fig.7.a gives the voltage, current and power waveforms of the input given to the boost converter. In the graph you can see that the current initially rises to a peak value as the motor starts and slowly reduces as the load increases. Accordingly, the power also varies with a peak power rise initially and settling as the graph progresses.

In Fig 7.b the waveforms of boosted output is being shown. When you take a look at the waveforms the voltage gets boosted by three times the input value and the boosted voltage becomes approximately 203V. This boosted voltage is obtained within a less settling time of around 0.2 sec. The current remains constant at 0.5 A because as the voltage gets boosted up the current reduces. The output power also gets boosted to 101.5W. The main reason for going to MRAC method is to reduce the transient oscillations associated with tracking the MPP and quickly reaching the MPP compared to the petrub and observe algorithm.

As one can see from the graph the boosted output settles very quickly within a time period of 0.2 to 0.5 seconds whereas it takes around 0.7-0.9 sec in petrub and observe algorithm from the simulation results.

VI. CONCLUSION

In order to improve the efficiency of photovoltaic systems, MPPT algorithms are used, aiming to deliver the maximum available power from the solar array to the load. Critical issues to be considered in the MPPT algorithms include system complexity, uncertainty, and dynamical performance. This paper developed a two-level adaptive control architecture that can reduce complexity in system control and effectively handle the uncertainties and perturbations in the photovoltaic systems and the environment. The first level of control was RCC, and the second level was MRAC. This paper focused mostly on the design of the MRAC algorithm, which compensated the underdamped characteristics of the power conversion system. In a sequel paper, we will provide a comprehensive analysis validating the coupling of MRAC with RCC.

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